GAS WELL FLOW INSTRUMENTATION

This is a continuation of application Ser. No. 56,271, filed May 26, 1987, now abandoned, which is a continuation of Ser. No. 660,130, filed Oct. 12, 1984, now abandoned.

FIELD OF THE INVENTION

The invention is related to gas well logging, and more particularly, to ascertaining the volume of gas produced by a natural gas well over a period of time.

BACKGROUND OF THE INVENTION

In the gas producing industry, information about the volume of gas flowing through a pipeline is extremely valuable to both gas producers and gas consumers. Production managers often find such information invaluable in making decisions about how to manage a particular well. Information about gas flow volume is also indispensable for determining the amount of money owed by a consumer to a producer. Often, a producer and a consumer each monitor the amount of gas flowing through their respective ends of a gas distribution pipeline. The producer bills the consumer based upon the producer's flow volume measurements. The consumer uses his own measurements to confirm the accuracy of the producer's measurements, and may dispute the amount which he has been billed if the producer claims a higher flow volume than the consumer himself has measured.

Circular chart recorders are widely used in the gas production industry for measuring the volume of gas flowing through a pipeline over a period of time. Such chart recorders provide a relatively inexpensive way to continuously permanently record gas flow volumes over predetermined time periods. Chart recorders usually plot two different flow parameters: differential pressure across a restriction placed in the pipeline, and static gas pressure in the pipeline at some distance from the restriction. From this information (together with atmospheric pressure and gas temperature), the volume of gas may be calculated in a well known manner.

Many commercially available chart recorders (such as, for instance, the Model 515A Recording Flow Meter manufactured by Reynolds Equipment Company of Garland, Texas) may be set to record data at different rates (e.g. seven days or 24 days). Such chart recorders selectivity rotate the circular chart onto which information is plotted at one of two different speeds depending upon desired measurement accuracy. A rapidly-rotating circular chart records measurements with a high degree of accuracy, but must be replaced often. A chart recorder which rotates its circular chart at a slower rate needs less attention, but produces less accurate results.

Of course, a circular chart recorder is only capable of recording flow rate versus time. The resulting charts must be interpreted to ascertain gas flow volume over a given time interval. Typically, such analysis is performed by manually ascertaining the area under the curves plotted on the chart. Although it is difficult to accurately determine the area under the curve of a plot, the accuracy of such determinations was sufficient in the past to provide reasonably accurate flow volume data for billing and other purposes.

As gas prices have increased, accuracy in the ascertainment of gas flow volumes has become extremely critical to both producers and consumers. Measurement

inaccuracies of even a few percent can translate into large billing errors. Because of the inherent inaccuracies of chart recorder logging, it is rare that the measurements taken by a producer exactly agree with the measurements taken by the consumer when chart recorders are used for logging. Moreover, measurements can be manipulated by intentionally overestimating or underestimating the area under the plotted curves of a chart, or by intentionally miscalibrating the chart recorder. Most chart recorders use simple mechanical linkages to connect flow sensing devices to the chart recorder pens. Such mechanical linkages are made adjustable to permit calibration of the chart recorder. It is a relatively simple operation for an unscrupulous producer or consumer to misadjust the mechanical linkages in its favor. Measurement inaccuracies, both inherent and intentional, result in contract disputes which often must be litigated in the courts, increasing the costs of doing business in the gas producing industry.

Attempts have been made in the past to increase gas well logging accuracy. The following U.S. patents disclose mechanical approaches to increasing logging accuracy:

U.S. Pat. No. 1,887,810 to Chamberlain (1932);
U.S. Pat. No. 2,556,803 to Eckman (1951);
U.S. Pat. No. 3,322,339 to Nolte (1967);
U.S. Pat. No. 1,977,498 to Staegemann (1934); and
U.S. Pat. No. 2,264,370 to Harrison (1941).

More recently, electronic circuitry has been used to replace mechanical well logging device components to achieve greater accuracy and versatility. For example, U.S. Pat. No. 4,414,634 to Louis et al (issued Nov. 8, 1983) discloses a microprocessor-based gas flow totalizer which translates the positions of the pens of a chart recorder into electrical signals and further processes the electrical signals to obtain flow volume over a period of time. This logging system (which is also disclosed in Brochure File No. 1800:215-2 published by Meriam Instrument of Cleveland, Ohio) features an optional split keyboard arrangement for permitting an electronic flow calculator to be used at multiple locations. U.S. Pat. No. 3,980,865 to Messer et al (1976) discloses an apparatus which uses optical encoders to convert the rotation of a chart recorder and angles of the swing of chart recorder pen arms to digital values which are accumulated and printed. U.S. Pat. No. 3,742,515 to Yeiser (1973) discloses an electronic integrator which continuously computes the area under a curve drawn by a chart recorder. U.S. Pat. No. 1,931,474 to Ryder (1933) teaches a hybrid electronic/mechanical chart recording apparatus for ascertaining rate of fluid flow.

Other attempts have been made to replace mechanical chart recording devices with entirely electronic measuring systems. See, for example, U.S. Pat. No. 4,149,254 to Molusis (1979), U.S. Pat. No. 3,752,393 to Mosley (1973), U.S. Pat. No. 3,407,658 to Kerbow et al (1968) and U.S. Pat. No. 2,611,812 to Hornfeck (1952), all of which disclose flow measuring devices making extensive use of electronic processing. See also U.S. Pat. No. 4,355,365 to McCracken et al (Oct. 19, 1982) and U.S. Pat. No. 4,150,721 to Norwood (1979), which disclose electronic gas well controllers.

SUMMARY OF THE INVENTION

Unfortunately, the electronic gas well logging devices which have been developed heretofore are not particularly user friendly, and are therefore difficult to operate by all except experienced engineers or produc-